

# Tru64 UNIX and Linux: A Side-by-Side Comparison



Gordon Voss  
Technical Consultant  
Transition Engineering and Consulting  
[Gordon.Voss@hp.com](mailto:Gordon.Voss@hp.com)

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- This session compares and contrasts the features of Tru64 UNIX to those of Linux in the areas of general system administration and installation, configuration for users and accounts, storage and file system management, process and job control as well as clustering and resource management capabilities. The talk is intended to leave the audience with a understanding of the relative strengths of the two operating environments.
- As Tru64 UNIX customers evaluate future replacement environments to their existing Tru64 installations over the next few years. Many will be evaluating a possible role for Linux as well the HP-UX. In general, customers relying on the advanced enterprise computing features of Tru64 UNIX will be more naturally drawn to HP-UX as the replacement, particularly after TruCluster and AdvFS file systems have been ported to HP-UX. On the other hand, the popularity, flexibility and alternative cost model of Linux makes it a viable alternative for Tru64 customers in the areas of application development, web interfaces, and increasingly as time goes on, database servers.

- Topics
  - Introduction
  - Brief Histories
  - UNIX Look and Feel
  - Storage Management Components
  - Scaling and Advanced Enterprise Features
- *Non-Topics*
  - *Open Source Development and Distribution Models*
  - *ISV availability*
  - *Performance via Alpha, Linux on I32*
  - *TOC or Economics*
  - *Service and Support Models*
  - *I32 implementation*
  - *HPTC*

# Tru64 UNIX and Linux



- Tru64 UNIX® ~88
  - starting point – 1988 Open Software Foundation's (OSF) OSF/1
    - low level kernel services – CMU Mach
    - higher level kernel services – BSD UNIX
    - compatibility APIs, libs and tools for SysV UNIX
  - (replaced Digital's earlier BSD based UNIX – Ultrix)
  - continued Digital/Compaq enterprise enhancements
    - SMP
    - Partitioning
    - Multipathing, ....
  - Proprietary Unix
    - Mature
    - Full set of enterprise features including scaling for large servers
    - Established traditional support model
- Linux ~94
  - started point - 1991 a project by then university student Linus Torvalds,
    - inspired by partly Minix
    - goal of a simple UNIX clone to run on 386-based PCs, independent of proprietary code
    - early on utilized GNU software and other UNIX code already covered by GPL
      - Kernel – Linux
      - Compilers, Tools and Basic User-mode Environment – GNU
      - Additional Components – Desktop, Installation, GUI Admin – Other Open Source Projects or Distributor
  - made available on the internet under GNU GPL license
    - Spawned a “Open Source Phenomenon” of collaborative work by programmers all over the world
    - Distributed under GPL by vendors like Red Hat and SuSe
  - Open Source Unix
    - “Free” – low cost
    - Flexible, go your own way
    - No lock in

# which Linux /platform to compare to Tru64 UNIX?



- for the purpose of this presentation;
  - distribution: Red Hat Enterprise Linux 2.1 AS
  - platform: HP Itanium Processor based Servers
- one of two distributions currently supported or certified for HP IPF servers
  - other is SuSe 8.0 based on United Linux UL 1.0
  - HP large contributor to Linux on IPF effort through Trillion project
  - assumption - official distributions on powerful platforms will be of most interest to customers when considering replacements for Tru64/Alpha in enterprise environments

# historical timelines



- Tru64 UNIX
  - ~85 Mach 2.5, OSF/1 – Micro-Kernel concepts, Kernel Threads, memory mapped files
  - ~88 DEC OSF/1 – LVM, SysV compatibility, Shared Libraries,
  - ~93 DEC OSF/1 1.2 - Alpha, 64-bit native OS, Unified Buffer Cache
  - 04/94 DEC OSF/1 2.0a – ASE 1.0 Cluster
  - 08/94 Digital UNIX 3.0 - SMP, AdvFS, LSM replaces LVM
  - 06/96 Tru64 UNIX 4.0 - CDE, sysman tools, UNIX 95
- Linux Kernel / Red Hat
  - 10/91 Linux 0.02
    - 93 ACC Corporation founded,
  - 03/94 Linux 1.0 – i386, uni-processor
    - 94 Marc Ewing creates first “Red hat” release
  - 03/95 Linux 1.2 – support for multiple CPU architectures (Alpha, MIPS,..)
    - 95 ACC buys out Ewing and creates Red Hat Software
    - 95 Red Hat Linux 2.0, includes RPM
  - 06/96 Linux 2.0 – more architectures, SMP
    - 7/97, Red Hat 4.2
    - 7/98 Red Hat - Oracle announces support

# historical timelines



- Tru64 UNIX

05/99 Tru64 UNIX 4.0f – Fibre Channel support

08/99 Tru64 UNIX 5.0 – TruCluster (TCR) Single-Image Clustering, device location independent naming, built-in self configuring storage Multi-Pathing

08/00 Tru64 UNIX 5.1 - NUMA (Global Switch), 32 CPUs, 128 GB physical memory

09/02 Tru64 UNIX 5.1B - NUMA (Fabric) , Big Pages, 256GB physical memory

*Next - Q3/03 Tru64 UNIX “Vail”, - 64 CPU, migration tools to HP-UX and common system management*

- Linux Kernel / **Red Hat**

01/99 Linux 2.2 – better SMP, wider hardware options

04/99 Red Hat 6.0

10/99 Red Hat 6.1

01/01 Linux 2.4 – more SMP scaling, better desktop USB, PCMCIA, P&P

01 7.1 includes 2.4 kernel, introduces software manager for red hat network – automatic bug notifications, software updates etc.

01/10 Red Hat 7.2

03/02 Linux Advanced Server ; Oracle, Veritas announce support

09/02 Red Hat 8.0

03/03 Enterprise family of operating systems products launched

04/03 Red Hat 9

*Next - Linux 2.6 16+ CPUs, True Asynchronous I/O, better user-threads*

# basic UNIX look and feel



- Linux was intended as a UNIX clone
  - “aims to be compliant with the IEEE POSIX standard”
- So many areas of basic user and admin environments are very similar or identical
  - user/group accounts
  - shells
  - file and directory commands
  - rooted tree and basic file system layout
  - process and job control including cron and at
  - system ascii logs
  - system start, run levels and shutdown
  - basic IP network interfaces and configuration



# users, groups and shells



## Tru64 UNIX® V5.1B

## Red Hat 2.1 AS IPF

user and group files

`/etc/passwd`  
`/etc/group`

`/etc/passwd`  
`/etc/group`

default user account definition

`/usr/skel`

`/etc/skel`

command-line utilities to add a user

`useradd, userdel`  
`adduser, removeuser`

`useradd, userdel,`  
`adduser, removeuser`

system-wide shell startup file

`/etc/profile`

`/etc/profile`

shell information

`/etc/shells`

`/etc/shells`

Bourne shell

`[/usr]/bin/sh`

Korn shell

`[/usr]/bin/ksh`

POSIX shell

`[/usr]/bin/posix/sh`

C shell

`[/usr]/bin/csh`

`/bin/bash (sym links`  
`/bin/sh, /bin/bash2)`

`/bin/csh, /bin/tcsh`

# manipulating files and file systems



## Tru64 UNIX® V5.1B

## Red Hat AS 2.1 IPF

user file and dir  
commands

`ls, cd, find,  
more ..`

`ls, cd, find,  
more, less...`

mounting/unmounting  
file systems

`mount, umount`

`mount, umount`

boot time mounted  
file systems

`/etc/fstab  
/sbin/bcheckrc`

`/etc/fstab  
/etc/rc.d/rc.sysinit  
/etc/init.d/netfs`

list mounted file  
systems

`df`

`df`

# file system directory hierarchy



	<b>Tru64 UNIX® V5.1B</b>	<b>Red Hat AS 2.1 IPF</b>
	/	/
device special files	/dev, /devices	<b>/dev</b>
configuration files	/etc	/etc
default user home dirs	/home, /usr/users	/home
fsck output area	/lost+found (UFS)	/lost+found
temporary mount	/mnt	/mnt, <b>/mnt/cdrom</b>
optional software	/opt, /usr/opt, /var/opt	<b>/var/opt</b>
single user-mode binaries	/sbin,	/sbin, <b>/bin</b>
single user-mode shared libs	/shlib	<b>/lib</b>
binaries	/sbin, /usr/bin, /usr/sbin (/bin sym link to /usr/bin)	/bin, /sbin, /usr/bin, /usr/ sbin
bootstrap, kernel	/vmunix	<b>/boot/efi/vmlinuz-X.X</b>
kernel config and build	/subsys, /sys	<b>/usr/src/linux-X.X</b>
	/tmp	/tmp
	/usr	/usr
libraries	/usr/lib, /usr/shlib	<b>/usr/lib</b>
	/var	/var
source area	NA	<b>/usr/src</b>

# man hier



```
[tru64] # man hier
hier(5)
```

## NAME

hier - Standard file system hierarchy

## DESCRIPTION

A Tru64 UNIX operating system has a standard file system hierarchy. So does the X11 Window System. The operating system has a unique root directory, the identity of which is compiled into the operating system kernel and is activated when the operating system is bootstrapped. The X11 Window System is a file system within the operating system hierarchy.

...

Base System Hierarchy	Description of Directory or File
/	The root directory for the root file system of the operating system
/cluster/	Directory for a cluster of which this system could be a member
members/	Root directory for cluster member0, this system, whether or not it is in a cluster
/dev/	Block and character device special files

...

```
[redhat] # man hier
HIER(7) Linux Programmer's Manual
```

## NAME

hier - Description of the file system hierarchy

## DESCRIPTION

A typical Linux system has, among others, the following directories:

- / This is the root directory. This is where the whole tree starts.
- /bin This directory contains executable programs which are needed in single user mode and to bring the system up or repair it.
- /boot Contains static files for the boot loader. This directory only holds the files which are needed during the boot process. The map installer and configuration files should go to /sbin and /etc.
- /dev Special or device files, which refer to physical devices. See mknod(1).

...

# basic processes and jobs



## Tru64 UNIX® V5.1B

process control `ps, kill, nice, renice`

cron, at, batch `/usr/sbin/cron`

`/var/adm/cron/cron.allow, cron.deny`

`/var/adm/cron/log`

`/var/spool/cron/crontabs/USER`

`/var/spool/cron/atjobs`  
*(handled as part of cron)*

## Red Hat AS 2.1 IPF

`ps, kill, nice, renice`

`/usr/sbin/crond`

`/etc/cron.allow, cron.deny`

`/var/log/cron`

`/var/spool/cron/USER, /etc/cron.d/XXX`

`/etc/crontab (system)`

`/var/spool/at`

`/var/spool/at/spool`

`/etc/at.allow`

`/etc/at.deny`

```
[tru64] # ps -ef
UID          PID    PPID      C  STIME     TTY          TIME CMD
root         524288      0    1.3   Jul 17  ??          06:36:05 [kernel idle]
root         524289  524288    0.0   Jul 17  ??          0:00.24 /sbin/init -a
root         524290  524288    0.0   Jul 17  ??          0:00.00 [kproc_creator_da]
```

```
[redhat] # ps -ef
UID          PID    PPID      C  STIME     TTY          TIME CMD
root          1      0      0  Aug06  ?           00:00:05 init
root          2      1      0  Aug06  ?           00:00:00 [migration_CPU0]
root          3      1      0  Aug06  ?           00:00:00 [migration_CPU1]
```

```
[tru64] # ps aux
USER          PID  %CPU  %MEM    VSZ   RSS TTY      S   STARTED          TIME COMMAND
root         524288  0.8   4.1  5.05G  169M  ??      R <   Jul 17          06:36:04 [kernel idle]
root         954155  0.1   0.0   2.52M   360K  console S     Aug 06          0:00.04 -ksh (ksh)
root         524564  0.1   0.0   3.45M   480K  ??      S     Jul 17          0:12.10 /usr/sbin/evmlogger ...
```

```
[redhat]# ps aux
USER          PID  %CPU  %MEM    VSZ   RSS TTY      STAT START   TIME COMMAND
root          1    0.0   0.0   2864  1296 ?        S     Aug06   0:05  init
root          2    0.0   0.0     0     0 ?        SW    Aug06   0:00  [migration_CPU0]
root          3    0.0   0.0     0     0 ?        SW    Aug06   0:00  [migration_CPU1]
```

## Tru64 UNIX® V5.1B

traditional  
ASCII logs

`/etc/syslog.conf`

`syslogd`

`/var/adm/syslog.dated/  
XXX/ [kern|daemon, ] .log`  
`/var/adm/messages`  
(kern.debug only)

kernel logs

*binary*

`/etc/binlog.conf`

`binlogd`

`/dev/kbinlog`

`/var/adm/binary.errlog`

## Red Hat AS 2.1 IPF

`/etc/syslog.conf`

`syslogd`

`/var/log/messages.X`

*ascii*

**embedded launch from**  
`/sbin/init.d/syslog`

`klogd`

`/proc/kmsgs`

`/var/log/messages via  
syslogd`

# boot trace in messages



```
[tru64] # more /var/adm/messages
```

```
...
Jun 24 19:29:30 localhost vmunix: Alpha boot: available memory from 0x3bbe000 to 0xffff4000
Jun 24 19:29:30 localhost vmunix: Compaq Tru64 UNIX P5.1B (Rev. 173); Tue Dec 17 15:49:27 E ...
Jun 24 19:29:30 localhost vmunix: physical memory = 4096.00 megabytes.
Jun 24 19:29:30 localhost vmunix: available memory = 3965.19 megabytes.
Jun 24 19:29:30 localhost vmunix: using 15646 buffers containing 122.23 megabytes of memory
Jun 24 19:29:30 localhost vmunix: Master cpu at slot 0
Jun 24 19:29:30 localhost vmunix: Starting secondary cpu 1
Jun 24 19:29:30 localhost vmunix: Starting secondary cpu 2
Jun 24 19:29:30 localhost vmunix: Starting secondary cpu 3
```

```
...
[redhat] # more /var/log/messages
```

```
...
Aug 6 21:04:25 localhost kernel: Inspecting /boot/System.map-2.4.18-e.31smp
...
Aug 6 21:04:25 localhost kernel: Loaded 16789 symbols from /boot/System.map-2.4.18-e.31smp.
Aug 6 21:04:25 localhost kernel: Symbols match kernel version 2.4.18.
Aug 6 21:04:25 localhost kernel: Error seeking in /dev/kmem
Aug 6 21:04:25 localhost kernel: Symbol #eepr100, value 00240000
Aug 6 21:04:25 localhost kernel: Error adding kernel module table entry.
Aug 6 21:04:25 localhost kernel: Linux version 2.4.18-e.31smp (bhcompile@natasha.devel.red ...
Aug 6 21:04:25 localhost kernel: EFI v1.02 by INTEL: SALsystab=0x7ff24e40 ACPI=0x7 ffda0c0 ...
Aug 6 21:04:25 localhost kernel: CPU 0: mapping PAL code [0x7ff40000-0x7ff7b000) into [0xe ...
...

```



# startup and shutdown



## Tru64 UNIX® V5.1B

## Red Hat AS 2.1 IPF

startup process  
/command

`init`

`init`

`(telinit)`

`/etc/inittab`

`/etc/inittab`

`(initdefault 3)`

`(initdefault 5)`

rc script(s)

`/sbin/rc[2|3]`

`/etc/rc.d/rc [0..6]`

rc directories

`/sbin/rc[0|2|3].d`

`/etc/rc[0..6].d`

subsystem start  
script

`/sbin/init.d/xxx`

`/etc/init.d/xxx`

subsystem  
settings

`/etc/rc.config`

`/etc/sysconfig/XX*`

shutdown

`shutdown, reboot`

`shutdown, reboot`

services  
abstraction

–

**via graphical tools**

# run levels



	<b>Tru64 UNIX® V5.1B</b>	<b>Red Hat AS 2.1 IPF</b>
Halt	<b>0</b>	<b>0</b>
Single User	<b>S</b>	<b>1</b>
Multi-User (gettys), fstab, no networking	<b>2</b>	<b>-</b>
Multi-User, networking interfaces	<b>-</b>	<b>2</b>
Mutli-User, full networking, fstab	<b>-</b>	<b>3</b>
Multi-user, full networking, X	<b>3</b>	<b>5</b>
Unused	<b>-</b>	<b>4,6</b>

# inittab



```
[tru64] # more /etc/inittab
...
id:3:initdefault:
ss:Ss:wait:/sbin/rc0 shutdown < /dev/cons ...
s0:0:wait:/sbin/rc0 off < /dev/console > ...
fs:23:wait:/sbin/bcheckrc < /dev/console ...
esm_init:23:wait:/sbin/init.d/esm init < ...
esmd:23:respawn:/usr/sbin/esmd </dev/null ...
kls:Ss:sysinit:/sbin/kloadsrv < /dev/cons ...
hsd:Ss:sysinit:/sbin/hotswapd < /dev/cons ...
sysconfig:23:wait:/sbin/init.d/autosyscon ...
update:23:wait:/sbin/update > /dev/consol ...
smsync:23:wait:/sbin/sysconfig -r vfs smo ...
smsyncS:Ss:wait:/sbin/sysconfig -r vfs sm ...
it:23:wait:/sbin/it < /dev/console > /dev ...
kmk:3:wait:/sbin/kmknod > /dev/console 2>&1
s2:23:wait:/sbin/rc2 < /dev/console > /dev ...
s3:3:wait:/sbin/rc3 < /dev/console > /dev/ ...
cons:1234:respawn:/usr/sbin/getty console ...
cms:s:sysinit:/sbin/sysconfig -o cms 100 > ...
```

```
[redhat] # more /etc/inittab
...
id:5:initdefault:
...
si::sysinit:/etc/rc.d/rc.sysinit
10:0:wait:/etc/rc.d/rc 0
11:1:wait:/etc/rc.d/rc 1
12:2:wait:/etc/rc.d/rc 2
13:3:wait:/etc/rc.d/rc 3
14:4:wait:/etc/rc.d/rc 4
15:5:wait:/etc/rc.d/rc 5
16:6:wait:/etc/rc.d/rc 6
...
ud::once:/sbin/update
...
ca::ctrlaltdel:/sbin/shutdown -t3 -r now
...
pf::powerfail:/sbin/shutdown -f -h +2 ...
...
pr:12345:powerokwait:/sbin/shutdown -c ...
...
co:012345:respawn:/sbin/agetty ttyS0 115200 ...
1:2345:respawn:/sbin/mingetty tty1
2:2345:respawn:/sbin/mingetty tty2
3:2345:respawn:/sbin/mingetty tty3
4:2345:respawn:/sbin/mingetty tty4
5:2345:respawn:/sbin/mingetty tty5
6:2345:respawn:/sbin/mingetty tty6
...
x:5:respawn:/usr/bin/kdm -nodaemon
```

# example nfs startup - scripts



```
[tru64] # find /sbin/rc* -name "*nfs*" -
print
/sbin/rc0.d/K30nfs
/sbin/rc0.d/K35nfsmount
/sbin/rc2.d/K35nfs
/sbin/rc2.d/K40nfsmount
/sbin/rc3.d/S19nfs
/sbin/rc3.d/S20nfsmount
[tru64] # ls /sbin/init.d/*nfs*
/sbin/init.d/nfs
/sbin/init.d/nfsmount
```

```
[redhat]# find /etc/rc.d -name "*nfs*" -
print
/etc/rc.d/init.d/nfs
/etc/rc.d/init.d/nfslock
/etc/rc.d/rc0.d/K20nfs
/etc/rc.d/rc0.d/K86nfslock
/etc/rc.d/rc1.d/K20nfs
/etc/rc.d/rc1.d/K86nfslock
/etc/rc.d/rc2.d/K20nfs
/etc/rc.d/rc2.d/K86nfslock
/etc/rc.d/rc3.d/K20nfs
/etc/rc.d/rc3.d/S14nfslock
/etc/rc.d/rc4.d/K20nfs
/etc/rc.d/rc4.d/S14nfslock
/etc/rc.d/rc5.d/S60nfs
/etc/rc.d/rc5.d/S14nfslock
/etc/rc.d/rc6.d/K20nfs
/etc/rc.d/rc6.d/K86nfslock
[redhat]# ls /etc/init.d/*nfs*
/etc/init.d/nfs /etc/init.d/nfslock
[redhat]# ls /var/lock/subsys/*nfs*
/var/lock/subsys/nfs
/var/lock/subsys/nfslock
```

# example NFS startup - settings



```
[tru64] # more /etc/rc.config
#!/bin/sh
...
#
. /etc/rc.config.common
DISPLAYTYPE=
MAX_NETDEVS=
NETDEV_2=
...
[tru64] # more /etc/rc.config.common
#!/bin/sh
...
NUM_NFSIOD="7"
export NUM_NFSIOD
AUTOMOUNT="1"
export AUTOMOUNT
AUTOMOUNT_ARGS="-v -D MACH=alpha -D OS=osf1 ..."
export AUTOMOUNT_ARGS
NFS_CONFIGURED="1"
export NFS_CONFIGURED
NFSSERVING="1"
export NFSSERVING
NFSLOCKING="1"
export NFSLOCKING
MOUNTOPTS="-i"
export MOUNTOPTS
NONROOTMOUNTS="0"
export NONROOTMOUNTS
...
```

```
[redhat] more /etc/init.d/nfs
...
nfs:RPCNFSDCOUNT=8
```

- Start links created and removed by GUI services tools as services are enabled and disabled. Less need for a NFSSERVING? Type flag
- autofs/automount flags are imbedding in /etc/init.d/autofs or are in /etc/auto.master.

# network interfaces and services



## Tru64 UNIX® V5.1 B    Red Hat AS 2.1 IPF

interface names	<code>lnX, eeX</code>	<code>ethX</code>
interface settings	<code>/etc/rc.config</code>	<code>/etc/sysconfig/network</code> <code>/etc/sysconfig/network-scripts/ifcfg-ethX</code>
show configured interfaces	<code>ifconfig -a</code>	<code>ifconfig -a</code>
network services daemon	<code>/usr/sbin/inetd</code>	<code>/usr/sbin/xinetd</code>
network services daemon config file	<code>/etc/inetd.conf</code>	<code>/etc/xinetd.conf</code> <code>/etc/xinetd.d/XXX</code>
network services config file	<code>/etc/services</code>	<code>/etc/services</code>
failover between physical NICs	<b>NetRAIN</b>	<b>Channel Bonding</b>
aggregation of physical NICs	<b>Link Aggregation (LAG)</b>	<b>Channel Bonding</b>

# ifconfig -a



```
[tru64] # ifconfig -a
ee0: flags=1000c63<UP,BROADCAST,NOTRAILERS,RUNNING,MULTICAST,SIMPLEX,CLUIF>
    inet 10.1.0.1 netmask ffffffff00 broadcast 10.1.0.255 ipmtu 1500

ee1: flags=c63<UP,BROADCAST,NOTRAILERS,RUNNING,MULTICAST,SIMPLEX>
...
lo0: flags=100c89<UP,LOOPBACK,NOARP,MULTICAST,SIMPLEX,NOCHECKSUM>
    inet 127.0.0.1 netmask ff000000 ipmtu 4096
...
tu0: flags=c63<UP,BROADCAST,NOTRAILERS,RUNNING,MULTICAST,SIMPLEX>
    inet 16.29.128.102 netmask ffffffff00 broadcast 16.29.128.255 ipmtu 1500
```

```
[redhat]# ifconfig -a
eth0      Link encap:Ethernet  HWaddr 00:03:47:D0:C8:C6
          inet addr:16.141.8.56  Bcast:16.141.8.255  Mask:255.255.255.0
          UP BROADCAST RUNNING MULTICAST  MTU:1500  Metric:1
          RX packets:2545655  errors:0  dropped:0  overruns:0  frame:0
          TX packets:504  errors:0  dropped:0  overruns:0  carrier:0
          collisions:4  txqueuelen:100
          RX bytes:351953576 (335.6 Mb)  TX bytes:45451 (44.3 Kb)
          Interrupt:49  Base address:0xf000

lo        Link encap:Local Loopback
          inet addr:127.0.0.1  Mask:255.0.0.0
          UP LOOPBACK RUNNING  MTU:16436  Metric:1
          RX packets:480  errors:0  dropped:0  overruns:0  frame:0
          TX packets:480  errors:0  dropped:0  overruns:0  carrier:0
          collisions:0  txqueuelen:0
          RX bytes:31846 (31.0 Kb)  TX bytes:31846 (31.0 Kb)
```

# interface settings



```
[tru64] # more /etc/rc.config
NETDEV_1=
NETDEV_2=
NETDEV_3=
NETDEV_4=
NETDEV_5=
NETDEV_7=
IFCONFIG_1=
IFCONFIG_2=
IFCONFIG_3=
IFCONFIG_4=
IFCONFIG_5=
IFCONFIG_7=
...
NETDEV_6="tu0"
export NETDEV_6
HOSTNAME="localhost.zko.dec.com"
export HOSTNAME
...
NETDEV_0="ics0"
export NETDEV_0
IFCONFIG_0="10.0.0.1 netmask 255.255.255.0 ..."
export IFCONFIG_0
IFCONFIG_6="16.29.128.102 netmask 255.255. ..."
export IFCONFIG_6
NUM_NETCONFIG="2"
export NUM_NETCONFIG
...
```

```
[redhat]# more /etc/sysconfig/network
NETWORKING=yes
HOSTNAME=yusuke
GATEWAY=16.141.8.1

[redhat]# ls /etc/sysconfig/network-scripts/ifcfg*
/etc/sysconfig/network-scripts/ifcfg-eth0
/etc/sysconfig/network-scripts/ifcfg-lo

[redhat]# more /etc/sysconfig/network-scripts/ifcfg*
:::::::::::::
/etc/sysconfig/network-scripts/ifcfg-eth0
:::::::::::::
DEVICE=eth0
BOOTPROTO=static
BROADCAST=16.141.8.255
IPADDR=16.141.8.56
NETMASK=255.255.255.0
NETWORK=16.141.8.0
ONBOOT=yes
:::::::::::::
/etc/sysconfig/network-scripts/ifcfg-lo
:::::::::::::
DEVICE=lo
IPADDR=127.0.0.1
NETMASK=255.0.0.0
NETWORK=127.0.0.0
# If you're having problems with gated making 127.0.0.0/8 a
  martian,
# you can change this to something else (255.255.255.255,
  for example)
BROADCAST=127.255.255.255
ONBOOT=yes
NAME=loopback
```



# kernel builds and configuration



## Tru64 UNIX® V5.1B

largely a re-link of  
subsystem modules

location of kernel

`/vmunix`

kernel build area

`/sys/HOST`

build definition file

`/sys/conf/HOST`

tools

`doconfig`

## Red Hat AS 2.1 IPF

largely a recompile from source files as  
well as linking

`/boot/vmlinuz-X.X` (EFI partition)

`/usr/src/linux-X.X/`

`/usr/src/linux-X.X/.config`

```
make oldconfig
make config | make menuconfig|make
xconfig
    make clean
    make dep
    make bzImage
    make modules
    make modules_install
    make install
```

# kernel build config file



```
[tru64] # more /sys/conf/localhost
ident      "localhost"

options    UERF
options    OSF
options    _LMF_
options    BIN_COMPAT
options    COMPAT_43
options    MACH
options    MACH_IPC_TCACHE
options    MACH_IPC_WWA
options    MACH_IPC_XXXHACK
options    BUFCACHE_STATS
...
```

```
[redhat]# make config
rm -f include/asm
( cd include ; ln -sf asm-i386 asm)
/bin/sh scripts/Configure arch/i386/config.in
#
# Using defaults found in configs/kernel-2.4.20-
# i686.config
#
*
* Code maturity level options
*
Prompt for development and/or incomplete code/drivers
(CONFIG_EXPERIMENTAL) [Y/n/?] n
*
* Loadable module support
*
Enable loadable module support (CONFIG_MODULES)
[Y/n/?]
Set version information on all module symbols
(CONFIG_MODVERSIONS) [Y/n/?]
Kernel module loader (CONFIG_KMOD) [Y/n/?]
...
more [redhat]# more .config
#
# Automatically generated make config: don't edit
#
CONFIG_X86=y
# CONFIG_SBUS is not set
CONFIG_UID16=y

#
# Loadable module support
#
CONFIG_MODULES=y
CONFIG_MODVERSIONS=y
CONFIG_KMOD=y
```

# kernel build procedure



```
[tru64] # doconfig

*** KERNEL CONFIGURATION AND BUILD PROCEDURE ***

Enter a name for the kernel configuration file. [localhost]:

A configuration file with the name 'localhost' already
exists.
Do you want to replace it? (y/n) [n]: y

Saving /sys/conf/localhost as /sys/conf/localhost.bck

*** KERNEL OPTION SELECTION ***

  Selection      Kernel Option
-----
--
  1      System V Devices
  2      NTP V3 Kernel Phase Lock Loop (NTP_TIME)
  3      Kernel Breakpoint Debugger (KDEBUG)
  4      Packetfilter driver (PACKETFILTER)
  ...
  20     All of the above
  21     None of the above
  22     Help
  23     Display all options again
-----
--

Enter your choices.

Choices (for example, 1 2 4-6) [21]: 20
...
Do you want to edit the configuration file? (y/n) [n]:
...
*** PERFORMING KERNEL BUILD ***

A log file listing special device files is located in
/dev/MAKEDEV.log
Working...Thu Aug 7 15:14:09 EDT 2003

The new kernel is /sys/localhost/vmunix
```

```
[redhat]# make clean
make[1]: Entering directory `/usr/src/linux-2.4.20-6/arch/i386/boot'
rm -f tools/build
rm -f setup bootsect zImage compressed/vmlinux.out
rm -f bsetup bbootsect bzImage compressed/bvmlinux.out
make[2]: Entering directory `/usr/src/linux-2.4.20-6/arch/i386/boot/compressed'
rm -f vmlinux bvmlinux _tmp_*
...

[redhat]# make bzImage
make[1]: Entering directory `/usr/src/linux-2.4.20-6/arch/i386/boot'
make[1]: Nothing to be done for `dep'.
make[1]: Leaving directory `/usr/src/linux-2.4.20-6/arch/i386/boot'
scripts/mkdep -- init/*.c > .depend
scripts/mkdep -- `find /usr/src/linux-2.4.20-6/include/asm
/usr/src/linux-2.4.20-6/include/linux /usr/src/linux-2.4.20-6/include/scsi /usr/src/linux-2.4.20-6/include/net
/usr/src/linux-2.4.20-6/include/math-emu \ ( -name SCCS -o
-name .svn \) -prune -o -follow -name \*.h ! -name
modversions.h -print` > .hdepend
make sfdep kernel sfdep drivers sfdep mm sfdep fs
sfdep net sfdep ipc sfdep lib sfdep crypto
sfdep arch/i386/kernel sfdep arch/i386/mm
sfdep arch/i386/lib FASTDEP ALL SUB DIRS="kernel
drivers mm fs net ipc lib crypto arch/i386/kernel
arch/i386/mm arch/i386/lib"
...
Root device is (3, 2)
Boot sector 512 bytes.
Setup is 4846 bytes.
System is 1033 kB
warning: kernel is too big for standalone boot from floppy
make[1]: Leaving directory `/usr/src/linux-2.4.20-6/arch/i386/boot'

[redhat]# make modules
make -r -f tmp_include_depends all
make[1]: Entering directory `/usr/src/linux-2.4.20-6'
make[1]: Circular /usr/src/linux-2.4.20-6/include/asm/smplock.h <- /usr/src/linux-2.4.20-6/include/linux/interrupt.h dependency dropped.
...
```

# kernel dynamic modules and interfaces



## Tru64 UNIX® V5.1B

## Red Hat AS 2.1 IPF

dynamically  
loadable kernel  
modules

`yes, rarely used`

`yes, commonly used`

module  
configuration

`sysconfig,`

`lsmod, modprobe,  
depmod, rmmod,`

boot-time loaded  
modules

`/etc/sysconfigtab  
/sbin/init.d/autosysc  
onfig`

`/etc/modules.conf`

dynamic kernel  
tuning

`sysconfig,  
/etc/sysconfigtab`

`sysctl,  
/proc/sys/subsys/param  
/etc/sysctl.conf`

# listing dynamically loaded kernel modules



```
[tru64] # grep "^SUBSYSTEM LIST="
/sbin/init.d/autosysconfig
SUBSYSTEM_LIST="hwautoconfig"

[tru64] ls /var/subsys
lat.mod          marvel_pfm.mod  marvel_pfm.mth
pfm.mod          pfm.mth

[tru64] # sysconfig -m | more
cm: static
hs: static
ksm: static
psm: static
generic: static
io: static
ipc: static
...
hwautoconfig: dynamic
envmon: dynamic
lat: dynamic
```

```
[redhat] more /etc/modules.conf
alias parport_lowlevel parport_pc
alias eth0 eeepro100
alias scsi_hostadapter qla1280
alias eth1 e100
alias sound-slot-0 cs4281
post-install sound-slot-0 /bin/aumix-minimal -f
/etc/.aumixrc -L >/dev/null 2>&1
|| :
pre-remove sound-slot-0 /bin/aumix-minimal -f /etc/.aumixrc
-S >/dev/null 2>&1 |
| :
alias usb-controller usb-uhci
[root@yusuke redhat]#
```

```
[redhat]# lsmod
```

Module	Size	Used by	Not tainted
nfs	221648	1 (autoclean)	
nfsd	195264	8 (autoclean)	
lockd	126480	1 (autoclean)	[nfs nfsd]
sunrpc	196544	1 (autoclean)	[nfs nfsd ...]
ide-cd	74744	0 (autoclean)	
cdrom	73464	0 (autoclean)	[ide-cd]
cs4281	122424	0 (autoclean)	
soundcore	14416	3 (autoclean)	[cs4281]
button	8808	0 (unused)	
autofs	31328	0 (autoclean)	(unused)
eeepro100	53488	1	
ipchains	110632	13	
nls_iso8859-1	6048	1 (autoclean)	
nls_cp437	7728	1 (autoclean)	
vfat	31096	1 (autoclean)	
fat	88664	0 (autoclean)	[vfat]
usb-uhci	70744	0 (unused)	
usbcore	176888	1 [usb-uhci]	
ext3	167144	2	
jbd	126688	2 [ext3]	
qla1280	128384	0	
sd_mod	33280	0	
scsi_mod	221600	2 [qla1280 sd_mod]	

# Now let's take a look at higher level functionality



- Storage management
  - Finding disk
  - Volume managers
  - File systems
  - Swap
- System Management tools
- Scaling
- SMP
- Clustering

# storage stack



## Tru64 UNIX® V5.1B

storage device  
naming

physical location  
independent (dskX)

software RAID /  
Volume Manager

LSM - licensed port of  
Veritas VxVM

software multi-  
pathing

built-in to single system and  
cluster, auto-configured and  
automatically used on all  
storage

BSD style file  
system

ufs

journal file system

AdvFS (owned and  
developed by HP)

other local rw file  
systems

-

## Red Hat AS 2.1 IPF

physical location  
dependent (hdX, sdX)

Multi Device (MD) Driver,  
LVM of IBM heritage

MD driver

ufs

ext3, reiserfs

ext2,  
msdos, vfat, .....

## Tru64 UNIX® V5.1B

## Red Hat AS 2.1 IPF

what disks?

```
hwmgr -show scsi, hwmgr  
-view dev
```

**hwbrowser (X)**

```
ls /proc/ide
```

```
more /proc/scsi
```

labels, partitions

```
disklabel
```

```
parted, fdisk
```

special file  
naming

```
dskXY
```

where:

**x**: digit(s) which tie the name  
to the WWID of a disk(LUN),  
independent of paths or  
detection order in a probe

**X**: letter [a..h] for  
partition

```
hdXY, sdXY
```

where;

**x**: letter(s) indicating  
the disk [a...z,aa..zz]  
based on detection  
order in probe

**y**: digit for a partition



# listing attached disks



```
[tru64] # hwmgr -view dev
```

```
HWID: Device Name      Mfg      Model      Location
-----
 6: /dev/dmapi/dmapi
 7: /dev/scp_scsi
 8: /dev/kevm
75: /dev/disk/floppy0c  3.5in floppy  fdi...
93: /dev/disk/dsk0c    COMPAQ      BB018222B8 bus-1-targ...
94: /dev/disk/cdrom0c  COMPAQ      CD-224E     bus-3-targ...
95: /dev/random
96: /dev/urandom
101: /dev/cport/scp0    HSG80CCL   bus-2-targ-...
113: /dev/disk/dsk911c  DEC        HSG80      IDENTIFIER=911
114: /dev/disk/dsk912c  DEC        HSG80      IDENTIFIER=912
115: /dev/disk/dsk913c  DEC        HSG80      IDENTIFIER=913
116: /dev/disk/dsk914c  DEC        HSG80      IDENTIFIER=914
117: /dev/disk/dsk915c  DEC        HSG80      IDENTIFIER=915
118: /dev/disk/dsk916c  DEC        HSG80      IDENTIFIER=916
316: /dev/disk/dsk921c  DEC        HSG80      IDENTIFIER=921
317: /dev/disk/dsk922c  DEC        HSG80      IDENTIFIER=922
318: /dev/disk/dsk923c  DEC        HSG80      IDENTIFIER=923
319: /dev/disk/dsk924c  DEC        HSG80      IDENTIFIER=924
320: /dev/disk/dsk925c  DEC        HSG80      IDENTIFIER=925
321: /dev/disk/dsk926c  DEC        HSG80      IDENTIFIER=926
322: /dev/disk/dsk927c  DEC        HSG80      IDENTIFIER=30
```

```
[redhat] # ls /proc/ide
```

```
drivers hda hdb hdc ide0 ide1 piix
```

```
[redhat] # more /proc/scsi/scsi
```

```
Attached devices:
```

```
Host: scsi0 Channel: 00 Id: 00 Lun: 00
```

```
Vendor: QUANTUM Model: ATLAS10K2-TY184L Rev: DA40
```

```
Type: Direct-Access ANSI SCSI rev...
```

```
Host: scsi0 Channel: 00 Id: 02 Lun: 00
```

```
Vendor: COMPAQPC Model: ATLAS10K2-TY184L Rev: DDC2
```

```
Type: Direct-Access ANSI SCSI rev...
```

# disklabels / partitions



```
[tru64] # disklabel -r dsk925
# /dev/rdisk/dsk925c:
type: SCSI
disk: HSG80
label: clu_member2
flags:
bytes/sector: 512
sectors/track: 254
tracks/cylinder: 20
sectors/cylinder: 5080
cylinders: 1400
sectors/unit: 7109115
rpm: 3600
interleave: 1
trackskew: 7
cylinderskew: 26
headswitch: 0 # milliseconds
track-to-track seek: 0 # milliseconds
drivedata: 0
```

8 partitions:

#	size	offset	fstype	fsize	bsize	cpg	#	~Cyl values
a:	524288	0	AdvFS				#	0 - 103*
b:	6582779	524288	swap				#	103*- 1399*
c:	7109115	0	unused	0	0		#	0 - 1399*
d:	0	0	unused	0	0		#	0 - 0
e:	0	0	unused	0	0		#	0 - 0
f:	0	0	unused	0	0		#	0 - 0
g:	3357949	393216	unused	0	0		#	77*- 738*
h:	2048	7107067	cnx				#	1399*- 1399*

```
[redhat] # parted /dev/hdc print
```

```
Disk geometry for /dev/hdc: 0.000-57220.458 megabytes
```

```
Disk label type: GPT
```

Minor	Start	End	Filesystem	Name	Flags
1	0.017	100.016	FAT		boot, lba
2	100.017	2100.016	linux-swap		lba
3	2100.017	4100.016	ext3		lba
4	4100.017	8100.016	ext3		lba

```
[redhat]#
```

# software RAID



## Tru64 UNIX® V5.1B

## Red Hat AS 2.1 IPF

### LSM

### LVM

### MD driver

Root Support	yes	yes (/boot /efi no)	yes (/boot/efi no)
Installation support	yes	yes	yes
Multi-pathing	NA (handled in IO stack)	no*	yes
Linear/Append	yes	yes	yes
RAID 0	yes	yes	yes
RAID 1	yes	no	yes
RAID 0+1	yes	no	yes
RAID 3/5	yes	no	4/5

# LSM and LVM abstraction comparison



abstraction	LSM	LVM
physical disk	disk media (dm)	physical volume (pv)
logical volume	volume(v)	logical volume (lv)
administrative unit of physical disks and logical volumes	disk group (dg)	volume group (vg)
group of physical volume with different HBAs	NA	physical volume group (pvg)
contiguous extent on a physical volume	subdisk (sd)	physical extent (pe)
contiguous logical extent of storage for use in a volume	plex (p)	logical extent (le)

# LSM and LVM

## command equivalence - physical volumes/disk media

### LSM

`voldisksetup` brings a disk under VxVM control  
1 in the `voldiskadm` menu adds or initializes one or more disks

`voldisk list` lists information about VxVM disks

### LVM

`pvcreate` makes a disk an LVM disk

`pvdisplay` displays information about physical volumes in a volume group

# LSM and LVM

## command equivalence - volume groups/disk groups

LSM		LVM	
voldiskadd/voldg init	creates a new disk group and/or adds disks to a disk group	vgcreate	creates a volume group
voldg list volprint	displays the contents of a disk group  displays information about all objects or a subset of objects.	vgdisplay	displays information on all volume groups.
voldiskadd	adds a disk to the disk group	vgextend	extends a volume group by adding one or more disks to it
voldg deport	deports a disk group from the system.	Vgexport	removes a volume group from the system
voldg import	imports a disk group.	vgimport	adds a volume group to the system by scanning physical volumes which have been exported using vgexport

# LSM and LVM

## command equivalence - logical volume / volume

LSM		LVM	
volassist	creates volumes with the make parameter	lvcreate	create a logical volume
volassist	increases a volume in size with the growto or growby parameter	lvextend	grow the size of a logical volume
volassist snapshot	the snapshot operation takes one of the attached temporary mirrors and creates a new volume with the temporary mirror as its one plex	-	
volcreco ver/volu me start	the vxrecover command performs resynchronize operations for the volumes, or for volumes residing on the named disks (medianame or the VxVM name for the disk)	-	

# MD driver software RAID



- In kernel, configuration?

- `cat /proc/mdstat`

- **config file** `/etc/raidtab`

```
raiddev /dev/md0
```

```
    raid-level                0
```

```
    nr-raid-disks            2
```

```
    persistent-superblock    0
```

```
    chunk-size                8
```

```
    device                    /dev/sda1
```

```
    raid-disk                  0
```

```
    device                    /dev/sdb1
```

```
    raid-disk                  1
```

...

- **raidtools**

- `lsraid, mkraid, raidstart, raidstop, raidreconf`



# journal file systems



	<b>Tru64 UNIX® V5.1B</b>	<b>Red Hat AS 2.1 IPF</b>
Journal File System	<b>AdvFS</b>	<b>ext3, reiserfs</b>
storage model	<b>multi-volume</b>	<b>single volume</b>
quotas	<b>yes</b>	<b>yes</b>
creating	<b>mkfdmn, mkfset</b>	<b>mkfs,</b>
	<b>-</b>	<b>e2label</b>
resize	<b>addvol, rmvol,</b> <b>mount -u -o extend</b>	<b>resize2fs (ext2),</b> <b>resize_reiserfs</b> <b>(reiserfs)</b>
conversion tools	<b>-</b>	<b>tune2fs (ext2 to ext3)</b>

# swap



## Tru64 UNIX® V5.1B

## Red Hat AS 2.1 IPF

supported containers

**partitions**

**partitions, files**

configured

**/etc/sysconfigtab**

**/etc/fstab**

addition/removal

**swapon -a**

**mkswap, swapon,  
swapoff**

status

**swapon -s**

**more /proc/swaps  
free**

# unified, graphical and distributed admin frameworks



## Tru64 UNIX 5.1B

## Red Hat AS 2.1 IPF

single system admin

`sysman`, `sysman station` - unified, graphical (curses, X, web)

collection of `redhat-xxxx` command line  
collection of X based admin tools ...

# limits/scaling



## Tru64 UNIX 5.1B

## Red Hat AS 2.1 IPF

CPU's

32

~ 4-8

Memory

256 GB

(132 – 16GB);  
96 GB on largest  
currently shipping IPF  
server rx5670

effective file system size

16 TB

2 TB through 2.4 kernel,  
16 TB in 2.5 LBD work  
backported in patches to  
2.4

lowest common  
denominator of kernel,  
volume manager, file  
system limits

threading

Kernel Threads

Kernel Light Weight  
Processes

NXM for User Mode

Nx1

Big Pages

Yes

Yes

NUMA

2nd Generation  
(5.1, 5.1B)

No

# SMP and resource management



## Tru64 UNIX® V5.1B

## Red Hat AS 2.1 IPF

SMP scheduling

soft processor affinity  
with binding options

soft processor affinity

CPU binding options

runon, processor  
sets, class scheduler

-

platform partitioning

HP Alpha Servers -  
hard partitions

HP IPF Servers -  
npartitions (hard)

resource manager

-

*Future HP GWM*

# commercial clustering



	<b>Tru64 UNIX® V5.1B</b>	<b>Red Hat 2.1 AS IPF</b>
<b>IP load balancing</b> to a collection of servers	<b>IP Routing is a component of TruCluster (See Below)</b>	<b>Advanced Server IP load balancing (Piranha)</b>
<b>failover clustering</b>	<b>was Available Server Environment (ASE) – now superseded by TruCluster Server</b>	<b>Advanced Server Cluster Manager</b>
<b>single image cluster</b> failover or parallel applications (Oracle9i RAC) using single cluster wide rooted-tree filesystem	<b>TruCluster Server</b>	<b>-</b>

Note: many other non-Red Hat clustering products exist for Linux including HP ServiceGuard for Linux

# non feature differentiation



- Service and support model
- ISV support
- future Enhancements
- vendor independence
- knowledgeable IT professional pool



**i n v e n t**



- Tru64 UNIX® doc set on-line
  - [http://www.tru64unix.compaq.com/docs/pub\\_page/doc\\_list.html](http://www.tru64unix.compaq.com/docs/pub_page/doc_list.html)
- Linux runtime environment for hp-ux
  - [http://h21007.www2.hp.com/dspp/tech/tech\\_TechSoftwareDetailPage\\_IDX/1,1703,5757,00.html](http://h21007.www2.hp.com/dspp/tech/tech_TechSoftwareDetailPage_IDX/1,1703,5757,00.html)